An Modified Un-Even Hexagonal Block Search Algorithm For Fast Motion Estimation In Video Coding

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ABSTRACT

Motion estimation is one of the important factors to be considered for video coding. In this paper, the main objective is to increase the motion estimation in terms of fast, low complexity and reduced cost. To do this, in this paper an Modified Un Even Multi Hexagonal grid search algorithm [MUEHS] developed to obtain fast motion estimation for video coding by using hybrid block matching and searching technique is integrated. There are various steps to be carried out in MUEHS algorithm and they are 1). Motion estimation with reduce the calculation redundancy is obtained by an adaptive ME scheme, 2). Computing statistical results of the motion vector.The experimental results obtained from MATLAB software is used to evaluate the our proposed algorithm efficiency and comparing the results existing algorithm results. From the results, Modified Un Even Multi Hexagonal grid search algorithm shows that, it is efficient in terms of time saving up to 20%.

Index Term— Motion Estimation, Motion Vector, Video Compression, Video Compensation, Video Coding.

1. INTRODUCTION

In general, data compression is the process of reducing the redundancy in the data. Video compression is a process in which several coding techniques are used to reduce redundancy in video data. The most commonly used techniques in video compression are spatial image compression and temporal motion compensation. Most of the video codecs use techniques similar to audio compression since there are also audio data to compress along with pixel data in video compression. Macroblocks are formed by grouping a number of pixels in a square-shaped block. These macroblocks of a frame is compared with that of the next frame and their difference is stored as data in the compression process. Whenever there is more detail about the background or there is more movement of pixels between frames, in that particular portion more data is encoded to conserve the video quality. In video sequences such as that of explosions or a vehicle travelling at a high speed the bitrate of the video should be increased to improve quality.In recent times the streaming of videos over the internet has claimed an important spot among several applications of internet. One of the most important causes of video streaming becoming so popular is because of its application in multimedia communication. In the process of streaming videos a system should send/receive dozens of separate frames per second in order to comprise a video. For this process the system requires a high speed of processing and low computational time. In the process of streaming memory storage requirement is a major problem. If the memory of the streamed video should be reduced then the image quality should be compromised. So to reduce the memory units and to maintain a good picture quality while video streaming, Video Compression is necessary and plays a vital role in multimedia communication. Video signal processing is one of the major research areas in Digital Signal Processing field. The process of studying motions of objects in video frames is called Motion Estimation (ME). Motion estimation technique can be used for video coding and compression. ME process can eliminate the redundancy of frames next to next in a video and it is the most used video compression technique in encoding schemes such as MPEG-2, MPEG-4. The traditional block matching technique makes the quality of the video reduce as the decoding processes on. The basic idea of video compression is reducing the redundancy of frames followed by each other which can be easily done by applying motion estimation and compensation techniques. In motion estimation the process of determining the motion vectors is the computationally costly process since in this process the best motion vector is selected and their coordinate displacement along with its similar block in preceded frames and their coordinate displacement are computed. After these calculations are made the redundancy is reduced by encoding the previous frame with best similar block along with the current frame. This process of motion estimation and compensation requires a high system operational speed and less computational time. This increases the complexity of several ME based video compression methods proposed earlier. For reducing this computational complexity of ME technique various methods are proposed such as block matching algorithm and block motion estimation.Block motion estimation is employed in several motion compensated video codec schemes such as ISO MPEG-1, 2, 4, H.263/264, in order to remove redundancy in frames. In this method unlike in ME where the complete frame is encoded only the best matching block is encoded because the lesser the information coded, lesser is the memory used. In this process the determining the best matched block is a very important procedure. The video frame is divided into blocks and the best matching block is determined by the similarity measurement in their pixels and their mean of square error (MSE). The best the matching block can get the best will be the encoding accuracy. This method proved to be much simpler and less expensive computationally than ME technique. A video file or data are mostly considered as a sequential frame of images. Normally searching algorithms produces best optimal values from the search video sequences.

2. PREVIOUS APPORACHES

In the previous researches, fast block motion estimation algorithms were used for motion estimation like the three step search algorithm [1], the four step search algorithm [2], the block-based gradient descent search algorithm [3] and the diamond search algorithm [4]. These algorithms are basically slow and provide poor results in terms of accuracy. On the other side, in order to improve the accuracy, the three step and the four step search algorithms are modified as new three step search and new four step search approaches have been proposed and they start searching from the center of the search window [5, 6]. Standard video coding techniques such as H.264/AVC is utilized in present video coding [7, 8]. Compared with other video coding standards, H.264/AVC obtains a better performance by utilizing a set of novel coding tools like spatial-domain intra prediction, variable block-size motion estimation (ME) [9, 10].

3. PROPOSED APPORACH

For motion estimation, H.264/AVC uses block –matching technique which partitions the current frame into many macro blocks. For example these macro blocks may be $16\ x\ 16, 8\ x\ 16, 16\ x\ 8, 8\ x\ 8, 8\ x\ 4, 4\ x\ 8,\ and\ 4\ x\ 4$. Each performs motion estimation and regards computational result as a candidate MV. Macro blocks are formed by dividing the current frame and the reference frame. Each block is matched to all locations within the search window of the previous frame. Most of the motion estimation search algorithms obtain MV as the sum of absolute differences (SAD) in integer prediction. SAD is defined as follows:

$$SAD(s, r(ref, m)] = \sum_{x=1,y=1}^{M,N} \left| s[x,y] - r[x - m_x, y - m_y] \right| \quad \text{--- (1)}$$

M and N are width and height of the current macro-block; x and y is the coordinate of the current macro block; s=s[x, y] is the actual value; r is the predicted value which is depend on ref which is the value of the reference frame and m= [mx, my] which is the coordinate of the current MV. First the minimum SAD is chosen and the corresponding MV is regarded as the candidate MV during motion estimation search which involves large computational working. Hence motion estimation search costs the main time of the whole encoding process. The entire block matching process is shown in Figure-1. MUEHS functions better than the Full Search algorithm and proved it is efficient in terms of reduced ME time, less packet drop with low BER. It provides several different initial search point predictions, to make the initial search point close to the best prediction point. The searching strategy of MUEHS algorithm starts with cursory search pattern and then turns to elaborate search patterns. By using multi patterns this algorithm avoids the disadvantage of easy to trap in local minima suffered by traditional fast algorithms. Also MUEHS employs self-adaptive early termination threshold which makes it more efficient by reducing the searching process

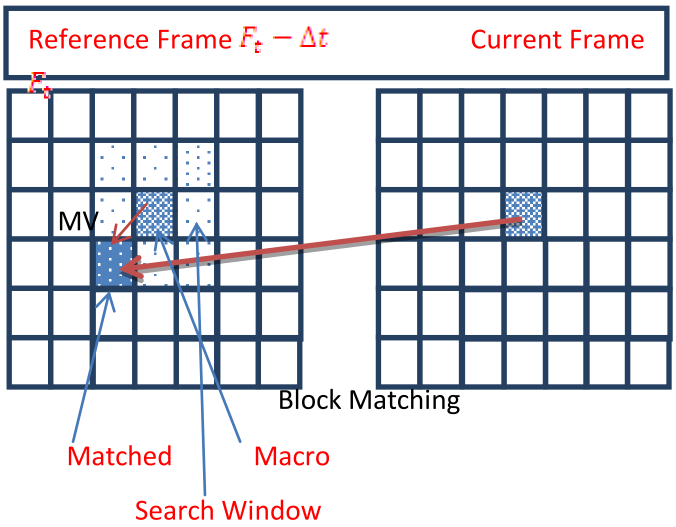

Fig-1: Block Matching Process

MUEHS algorithm causes a lot of unnecessary search points prediction reveals that it does not combine pattern search and MV characteristics. Each search step produces non uniform distributed MVs helps to find the best matched point without traversing all search points MUEHS algorithm was optimized in following ways

- Designing a new uneven multi hexagon-grid search pattern by progressively decreasing the layers of search points by decreasing the search radius
- The layers of uneven multi hexagon-grid search pattern are selected using the macro block motion intensity
- This motion intensity helps in selecting whether to perform 4 x 4 full search pattern

Analysis of MV distribution characteristics

MUEHS algorithm uses the uneven multi hexagon grid search which has vast range of search point's results in increased cost and time for search.

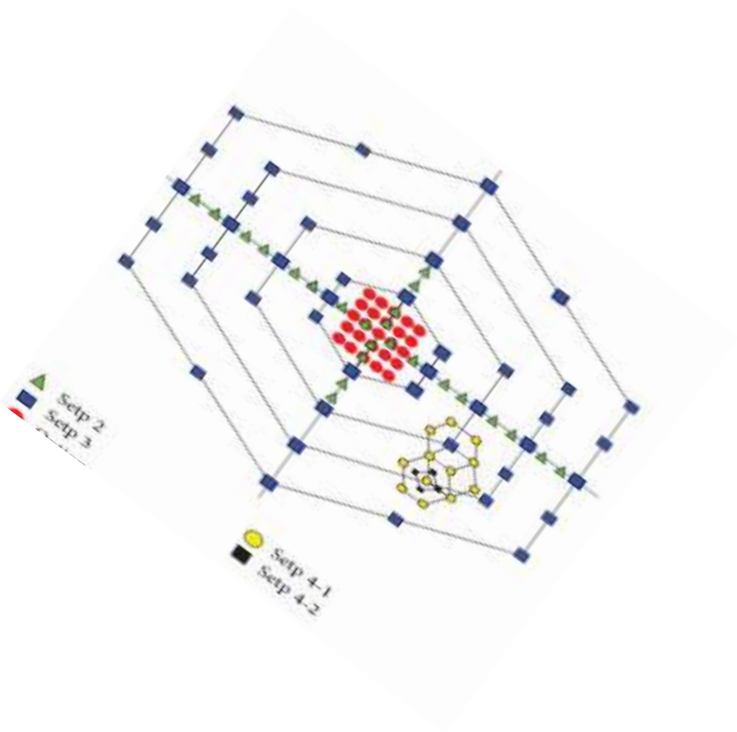

Fig-2: UEH Search Algorithm

By decreasing the search points we can gradually decrease the cost and time of the search. In order to do that it is analyzed the MV distribution characteristics. By dividing the search window into multilayer octagon we can obtain the statistic of MV distribution. Figure.2 shows such a MV distribution statistics. There will be no motion at the center regions which indicates that MV may nearly equal to 0. Other region positions the best match points in the figure. And all these regions can be defined using certain range as below.Each range is divided into three distinct layers from inside to outside which contains 13 regions. The best matched point probability can be found by using the H.264/AVC software, by taking JM18.4 as experimental platform and by choosing seven random QCIF formats (176 x 144) standards test sequences. The curves are drawn in the figure . From the table it is clear that BUS video sequence with low foreground motion and high background motion, the best match points appear in Layer1-Range1(36.20%), Layer1-Range3(13.80%) and Layer3-Range1(10.32%) reveals that distribution of MVs are dispersed. The distributed sequences in the layers are uneven and it is shown in the result.

Design Patterns

By using MV distribution prediction, the search position can be pinpointed without any large search range so it is needed to divide the patterns and to draw up new search tactics. As shown in fig 3, the unsymmetrical cross search pattern gets divided up to 4 groups. There exist 8 search points in horizontal groups and 4 search points in vertical groups. By MV prediction, the match point is found out among the four groups during the process of motion estimation. After modifying the patterns are compressed as 1/3 0r 1/6 and compared to the original pattern.

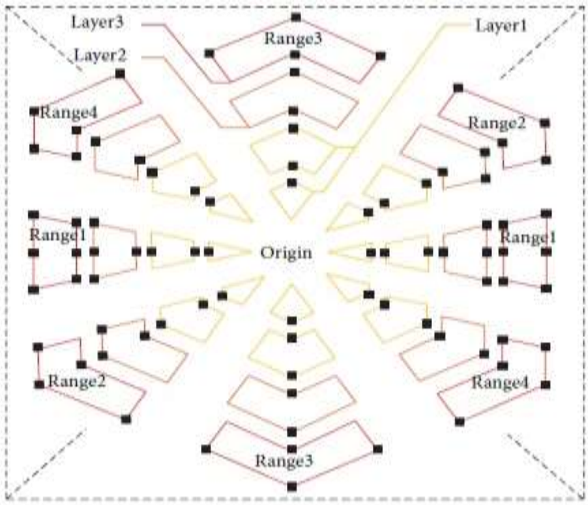

Figure-3: Modified Un-Even Multi-Hexagonal Pattern Searching

From fig 3 it was identified that the algorithm's uneven multi hexagon grid search pattern is divided into 32 regions. The search points are in uneven distribution either located close to the center or to the boundary. Layer 1 – 16 regions total 24 search points. Layer 2 – 4 regions and 22 search points. Layer 3 – 4 regions and 38 search points. To meet characteristic 1, 62 total 6 search points are distributed in ± 45∘ horizontally and 22 total search points are distributed in ±45∘ vertically. As previous manner matched point are searched in 32 regions and the pattern is compressed to 1/5 10 1/10 in layer 3 and 1. Finally it is compared to the original pattern.

To accelerate the estimation process, the search patterns are skipped at the instant when MV distribution prediction gets zero. In this case MV is considered as the center. This process not only maintains motion accuracy but also avoids some search points. It also decreases estimation encoding time.

Prediction of MV Distribution

In order to predict distribution of MV, the size and direction has to be predicted.

Size prediction:

The MV size is gained by comparing the MV macro block to the predicted threshold value.

The parameters related to predicted threshold value are:

- $(1+\gamma)\ pred_{mincost}$ - Upper limit threshold of the MV prediction.
- $(1+\delta)\ pred_{mincost}$ - Lower limit threshold of the MV prediction.
- $pred_{mincost}$ - minimum $RD_{mincost}$ of the predicted MV.
- $RD_{mincost}$ - Rate-distortion value calculated during the motion estimation

$$J_{motion}(mv, ref \mid \lambda_{motion}) = SAD\ [s, r(ref, m)] + \lambda_{motion} \quad \ldots Eqn\ (1)$$

In estimation of motion,

J_{motion} - $RD_{mincost}$

$pred$ – predicted MV.

R – Bit number of difference cost.

λ_{motion} – Lagrange parameter.

The only criterion to obtain MV is the sum of absolute differences. (SAD)

$$SAD\ [s, r(ref, m)] = \sum_{x=1, y=1}^{M,N} \left| s[x, y] - r\ [x - m_x, y - m_y] \right| \quad \ldots Eqn\ (2)$$

Where $M and\ N$ are the width and height of the current macroblock respectively;

x and y is the coordinate of the current macroblock;

$s = [x,]$ is the actual value; r is the predicted value. It depends on ref and m.

ref is the value of the reference frame.

$m = [m_x, m_y]$ is the coordinate of the currentMV, where m_x, m_y are the horizontal and vertical motion components respectively.

Predict MV Direction

The direction of MV, $\overrightarrow{MV}$ is described as the direction vector when the coordinates are assumed as MVx ,MVy . The direction will predict the distribution of MV in which range and which group. The parameter k should be defined which represents MV direction.

$$k = \left|\frac{MV_y}{MV_x}\right|$$

$\dots. Eqn\ (5)$

Thus by predicting the size and direction, accurate distribution of MV can be found. The distribution prediction is the condition for selecting the search areas of modified patterns.

Framework of Proposed Scheme

In the above fig.3, the proposed motion estimation algorithm is shown.This includes about median prediction, Up layer, corresponding block prediction and finally neighboring reference frame prediction. The next step involves choosing the MV which has the smallest rate distortion cost. The prediction of median belongs to the spatial prediction. It uses up to neighbor macroblocks in the same frame itself.

E will be surrounded by the same encoded blocks A,B, C having the same feature. Thus the current predicted $MV_{E\ is}$ predicted by A,B,C as MV_A, MV_B,MV_C. This is explained from the below equation as :

$$MV_E = \text{median}\ [MV_A, MV_B, MV_C]$$

$\dots. Eqn\ (6)$

The prediction of up layer fits to spatial prediction. The various sizes are used such as the small size can be predicted by the large blocks since it was a segment of macroblock.

$$MV_{current} = MV_{uplayer}$$

$\dots. Eqn\ (7)$

Corresponding block prediction fits into temporal prediction. The correlation of the corresponding frame was used here. The different macroblocks in the current frame with same position and in the previous frames are considered in such a way that the predicted MV_t is predicted with the help of MV_{t-1} with the same position in the previous frame itself. This is depicted in the following equation as:

$$MV_t = MV_{t-1}$$

$\dots.$ □□□ (8)

Neighboring reference frame prediction also belongs to temporal prediction. Reference frames are used. It is same as that of previous one but slightly better in providing accuracy. The MV_{pred_ref} is predicted with MV_{ref} . This is described in the following equation as:

$$MV_{pred\_ref} = MV_{ref} * \frac{\square - \square'}{\square - \square' - 1}$$

$\dots.$ □□□ (9)

In MV distribution prediction the size and direction of MV will be predicted from the previous steps. The search group in the modified unsymmetrical cross search pattern was chosen. After this the size is predicted. If the size of MV distribution prediction is zero then the eqn 6 is skipped or any layer in modified uneven multi-hexagonal grid search is specifically chosen. The extended hexagon search and extend method of diamond search are all performed in steps 8 and 9. In this search, hexagon patterns searches repeatedly until the best match points were found. In diamond search the small diamond pattern was used to search repeatedly till the final MV is obtained. Thus after all these steps, the motion estimation is finished.

3. EXPERIMENT RESULTS

In this paper, two video sequences as been analysed using MATLAB software.The City nad Mobile graph sequences output is given.

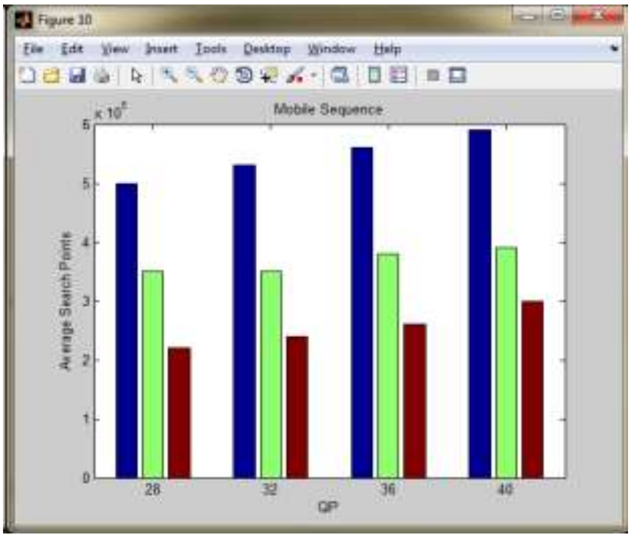

Figure-4: Average Search Points for Mobile video Sequence

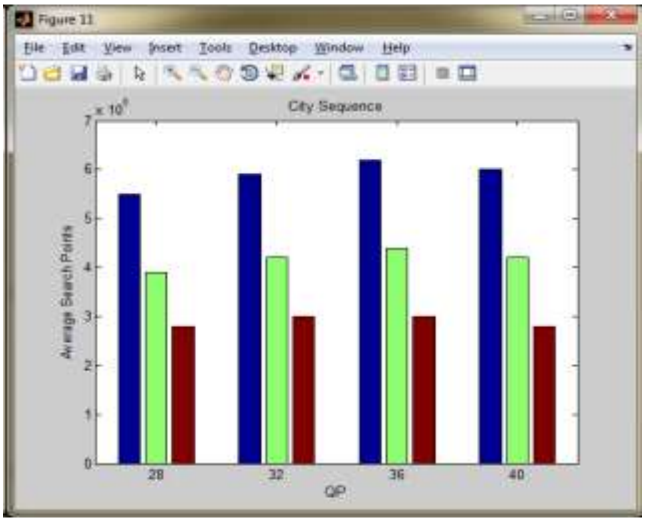

Figure-5: Average Search Points for City video Sequence

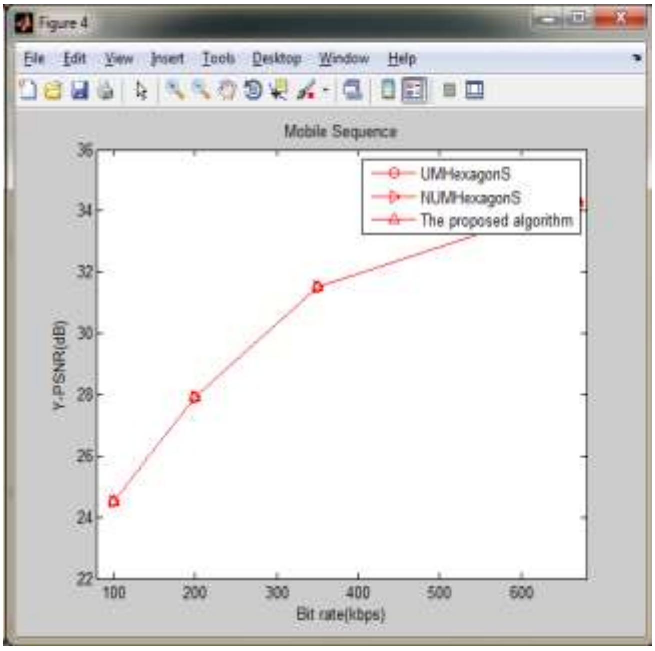

Figure-6: Average PSNR Values for Mobile video Sequence

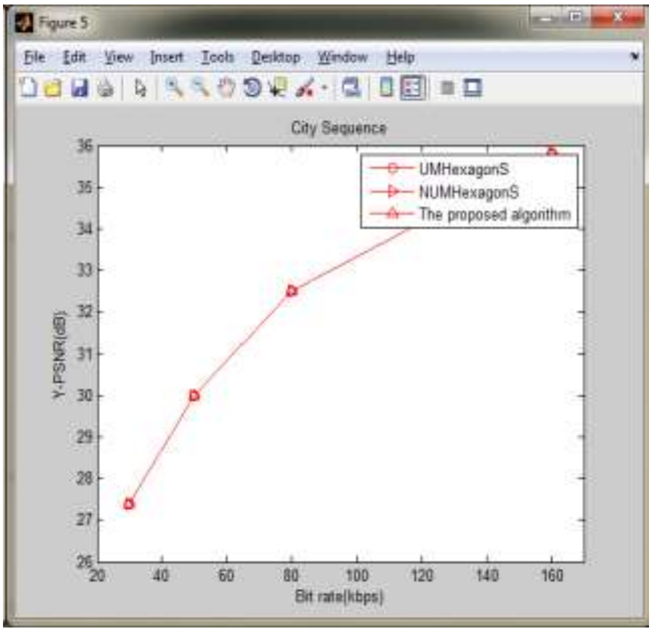

Figure-7: Average PSNR Values for City video Sequence

4. CONCLUSIONS

In this paper, a fast and flexible ME method is proposed named UEHS. MUEHS utilizes the motion continuity, motion integrity and MV distribution prediction with the Un-Even Hexagonal search pattern. The search pattern searches the potion on the frame more accurately. The MV distribution prediction methodology selects the direction by predicting the motion vector direction in terms of MV size. After that UEHS narrowed the search range of the ME and reduces the unwanted search points. The experimental results of MUEHS decreased the ME time and reduce the search points comparing with the JM18.4 algorithm. The proposed approach improves the efficiency of the H.264/AVC real time encoding by combining the video coding and prediction.

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